PB86-190048

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(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Apr 86

U.S. Department of Commerce
National Technical Information Service
NTIS.

EPA/600/D-86/088
April 1986

PB86-190048

CHARACTERIZATION OF ORGANIC EMISSIONS FROM SELECTED MATERIALS IN INDOOR USE

by

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EPA Contract 68-02-3988

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/D-86/088	2.
3. RECIPIENT'S ACCESSION NO. PB86 190048/AS	
4. TITLE AND SUBTITLE Characterization of Organic Emissions from Selected Materials in Indoor Use	5. REPORT DATE April 1986
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) B. A. Tichenor (EPA/AEERL) and M. A. Mason (Acurex)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Acurex Corporation Research Triangle Park, North Carolina 27709	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. 68-02-3988
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Air and Energy Engineering Research Laboratory Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Published Paper; 3/86
	14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES AEERL project officer is Bruce A. Tichenor, Mail Drop 54, 919/541-2991.

16. ABSTRACT The paper provides data from small-chamber testing of a latex caulk and a floor adhesive, as part of EPA's ongoing evaluation of organic emissions from indoor materials. Among the conclusions drawn from presented data are: (1) low air exchange rates promote high concentrations of organic vapors emitted from indoor sources; (2) high air exchange rates promote rapid vaporization of organics, leading to high emission factors in the initial testing phase; (3) cumulative mass emissions at the end of the testing period are approximately equal for all air exchange rates; and (4) organic emissions for different materials vary widely. Further research could provide additional valuable information, including identifying critical parameters affecting chamber emissions for a variety of building materials and consumer products. Research is underway to determine how changes in temperature and humidity affect organic emissions. Efforts continue to improve upon available models for relating chamber test conditions to emissions. Models to scale up chamber data to homes and other buildings are also under development. As more research is conducted and experience gained, small chamber evaluations of indoor sources of organic emissions should play a major role in developing data and information useful in the solution of the indoor air pollution problem.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Air Pollution	Organic Compounds	Air Pollution Control	13B	07C
Houses	Properties	Stationary Sources	13M	
Latex	Analyzing	Indoor Air Quality	11J	14B
Caulking		Floor Adhesives	13J	
Adhesives		Characterization	11A	
Emission			14G	

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 16
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

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Introduction

Indoor Air Quality (IAQ) is receiving increased attention by researchers and regulators as a critical component of the total exposure of humans to a variety of air pollutants. Studies in both the United States and Europe have shown indoor concentrations of several pollutants at levels in excess of outdoor ambient concentrations. A variety of indoor sources have been implicated as causes of these high concentrations. Combustion sources (e.g., cigarettes, wood stoves, kerosene heaters) emit NO_x, CO, and organics (gaseous and particulate). Natural sources can cause elevated levels of radon and microorganisms. Building materials and consumer products are potential sources of a wide variety of organic emissions, including formaldehyde.

In 1983, Congress mandated that EPA, in cooperation with other Federal agencies, develop plans and conduct research on IAQ. This work, initiated in fiscal year 1984, has included activities in measurement/monitoring, health effects, and source characterization. Tucker[1] provides a comprehensive description of EPA's overall IAQ research program. As part of EPA's research on source characterization, the Air and Energy Engineering Research Laboratory is conducting studies in small environmental chambers to develop organic emissions data on a variety of building materials and consumer products commonly used in homes.

Our research on small chamber evaluation of organic emissions from indoor materials has several objectives:

- develop techniques for rapid screening of products for organic emissions;
- determine the effect of environmental variables (i.e., temperature, humidity, air exchange) on emission rates;
- rank various products and product types with respect to their emissions profiles (e.g., emission factors, specific organics emitted);
- provide compound-specific data on various organic sources to guide field studies and assist in evaluating "sick" buildings;
- provide emissions data for the development and verification of models used to predict indoor concentrations of organics;
- develop data useful to manufacturers and builders for assessing product emissions and developing control options.

Sanchez, et al.[2] have reported on the performance of the test chambers with respect to control of environmental variables and recovery of organic emissions. Merrill, et al.[3] presented protocols for screening materials via headspace analyses using GC/MS. Dunn[4] proposed models and statistical methods for evaluating organic emissions data collected from the chambers. Previous papers[2,4] focused on the evaluation of emissions from a water based floor adhesive with emphasis on total measured organics. Tichenor, et al.[5] reported on tests conducted on a clear acrylic latex caulk with silicone; data on both total measured organics and selected organic species were presented. Nelms, et al.[6] provided results from the testing of particleboard under various environmental conditions,

reporting data on formaldehyde and several organic species. This paper provides data from chamber testing of a latex caulk and a floor adhesive. The effect of air exchange rate on emission factors is explored, and the emissions from the two materials are compared.

Experimental Facility

Design and construction of EPA's Environmental Test Chamber (ETC) facility was completed early in 1985. The basic components of the system are shown schematically in Figure 1 and include the following sub-systems: clean air conditioning and delivery, Environmental Test Chambers (two at 166 liters each), sampling manifolds, and sample concentration on Tenax and charcoal. A permeation system for quality control standard addition is included. The environmental variables are monitored and controlled via a micro-computer (IBM PC) based system. Organic analyses are conducted by thermal desorption from Tenax traps to the concentrator column of a purge and trap device, followed by rapid thermal desorption to the column of a gas chromatagraph equipped with an FID. (The GC data reported herein were collected on a Tracor 222; the present system employs a Perkin-Elmer Sigma 2000.) A separate micro-computer (Perkin-Elmer 7500) provides GC data analysis. Sanchez, et al.[2] provided a complete description of the facility. They also reported on the initial system shakedown and mechanical performance testing. A series of 10 randomly ordered tests (including two replicates) were conducted over the following ranges of environmental variables: temperature, 23 to 40°C; relative humidity, 40 to 60 percent; and air flow, 1.3 to 6.5 liters/min. These tests showed that the system can hold environmental variable setpoints to within the following limits:

temperature, ±0.1°C;
relative humidity, ±2.0 percent;
air flow, ±0.7 percent of reading.

Experimental Methods

The test materials were spread evenly over a square aluminum plate and placed in the ETC as soon as possible. For the floor adhesive, a top loading chamber was used and pressure tested prior to being placed in the incubator. The tests on the latex caulk were conducted with improved, front loading chambers which do not have to be removed from the incubator. Once the sample was placed in the ETC (and in the incubator), flow was initiated. Shortly thereafter, generally within 30 minutes, the first sample was withdrawn. Samples were collected on Tenax and analyzed via GC/FID after thermal desorption and concentration. Table I provides the operating conditions for the gas chromatograph.

Five separate tests are reported herein. Table II presents the test conditions. All tests were conducted at a temperature of 23°C and a relative humidity of 50 percent.

Results

This paper reports on the effect of air exchange rates on emissions of total measured organics. The analytical technique used limits the measure

organics to those in the C-4 to C-8 range. The emissions from the floor adhesive consisted predominantly of C-6, C-7, and C-8 alkanes and alkenes, both saturated and unsaturated; several cyclic compounds were observed. The latex caulking compound emissions consisted mainly of a C-8 alcohol, a C-7 ester, and a C-4 ketone; also included were other esters and ketones, both saturated and unsaturated alkanes and alkenes, and aromatics. More specific details on the composition of the emissions from these two materials are reported elsewhere[3,5].

Figures 2 and 3 provide log-log plots of the concentrations vs. time of total measured organics for the floor adhesive and latex caulk, respectively. The relationship between concentration and air exchange rate is clear; the lower the air exchange, the higher the concentration.

Emission factors can be calculated by multiplying the concentration by the chamber air flow and dividing by the sample size. Figures 4 and 5 show how the emission factors vary over time for the adhesive and caulk, respectively. The emission factor units are different for each material (i.e., (mg/sq m-hr) for the floor adhesive; (μg/g-hr) for the latex caulk). Note how the air exchange rate affects the emission factors over time. Initially, the emission factors are highest for the high air flows, indicating that the organics are rapidly vaporized at high air exchange rates. The emission factors for all air flows decrease with time. The rate of decrease is higher for the high air exchange rates, so within an hour or so, the emissions factors for the low air flow become the largest.

By integrating the emission factor curves over time, cumulative mass emissions vs. time can be obtained, as shown by Figures 6 and 7. (Again, note the different units for the two materials.) For the floor adhesive (Figure 6), the cumulative mass emissions for the 1.8 and 0.72/hr exchange rates are equal after about 10 hours; the cumulative emissions for the 0.36/hr rate are approximately 15 percent lower. The caulking compound data (Figure 7) show the cumulative emissions for the two air exchange rates being equal after about 60 hours. Figure 8 compares the cumulative mass emissions of the two materials by converting the caulk emissions data to the same units used for the floor adhesive. The floor adhesive is obviously a high emitter compared to the caulk; the y-axis is logarithmic, and the difference between the two lines is approximately two orders of magnitude.

Conclusions

Several conclusions can be drawn from the data presented:

* Low air exchange rates promote high concentrations of organic vapors emitted from indoor sources.

* High air exchange rates promote rapid vaporization of organics, leading to high emission factors in the initial testing phase.

* Cumulative mass emissions at the end of the testing period are approximately equal for all air exchange rates.

* Organic emissions for different materials vary widely.

These results indicate the desirability of high air exchange rates during the application of caulks, adhesives, and other similar materials. Increased ventilation causes rapid volatilization of organics and high emission rates, but the high air flow promotes reduced indoor concentrations of organics by dilution and increased air exchange. Additional testing of other types of materials is needed to confirm similar benefits of high air exchange rates.

Further research is also required to identify critical parameters affecting chamber emissions for a variety of building materials and consumer products. Research is underway to determine how changes in temperature and humidity affect organic emissions. Efforts continue to improve upon available models for relating chamber test conditions to emissions. Models to scale-up chamber data to homes and other buildings are also under development.

As more research is conducted and experience gained, small chamber evaluations of indoor sources of organic emissions should play a major role in developing data and information useful in the solution of indoor air pollution problems.

References

1. W. Tucker, "EPA Research on Indoor Air Quality." Paper No. 86-11.5, APCA Annual Meeting, Minneapolis, MN, June 1986.

2. D. Sanchez, M. Mason, C. Norris, "Methods and Results of Characterization of Organic Emissions from Indoor Materials." Presented at Workshop on Characterization of Contaminant Emissions from Indoor Sources, Chapel Hill, NC, May 1985.

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4. J. Dunn, "Models and Statistical Methods for Gaseous Emission Testing of Static Sources in Well-Mixed Chambers." Presented at Workshop on Characterization of Contaminant Emissions from Indoor Sources, Chapel Hill, NC, May 1985.

5. B. Tichenor, M. Jackson, R. Merrill, "Measurement of Organic Emissions from Indoor Materials -- Small Chamber Studies." Presented at EPA/APCA Symposium on Measurement of Toxic Air Pollutants, Raleigh, NC, April 1986.

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TABLE I - GC/FID CONDITIONS

Instrument:	Tracor 222 Gas Chromatograph with a flame ionization detector
Data System:	Perkin-Elmer 7500 Computer with LCI 100 Integrator
Column:	60/80 Carbopack B/1% SP-1000 10 ft (3.05 m) x 2 mm ID glass
Temperature Program:	50°C for 5 min to 225°C at 10°C/min, 15 min final hold
Temperatures	
Clamshell:	190°C
Purge and Trap Concentrator:	190°C
Detector:	250°C
Gases	
Helium:	30 ml/min
Hydrogen:	40 ml/min
Air:	400 ml/min

TABLE II - TEST CONDITIONS

Test No.	Material	Sample Weight (g)	Sample Area (sq cm)	Chamber Flow (l/m)	Air Exchange (/hr)
AD113	Floor Adhesive	0.108	8.86	5.0	1.8
AD121	Floor Adhesive	0.095	8.44	2.0	0.72
AD131	Floor Adhesive	0.093	8.88	1.0	0.36
CK114	Latex Caulk	4.89	361.0	5.0	1.8
CK131	Latex Caulk	5.07	361.0	1.0	0.36

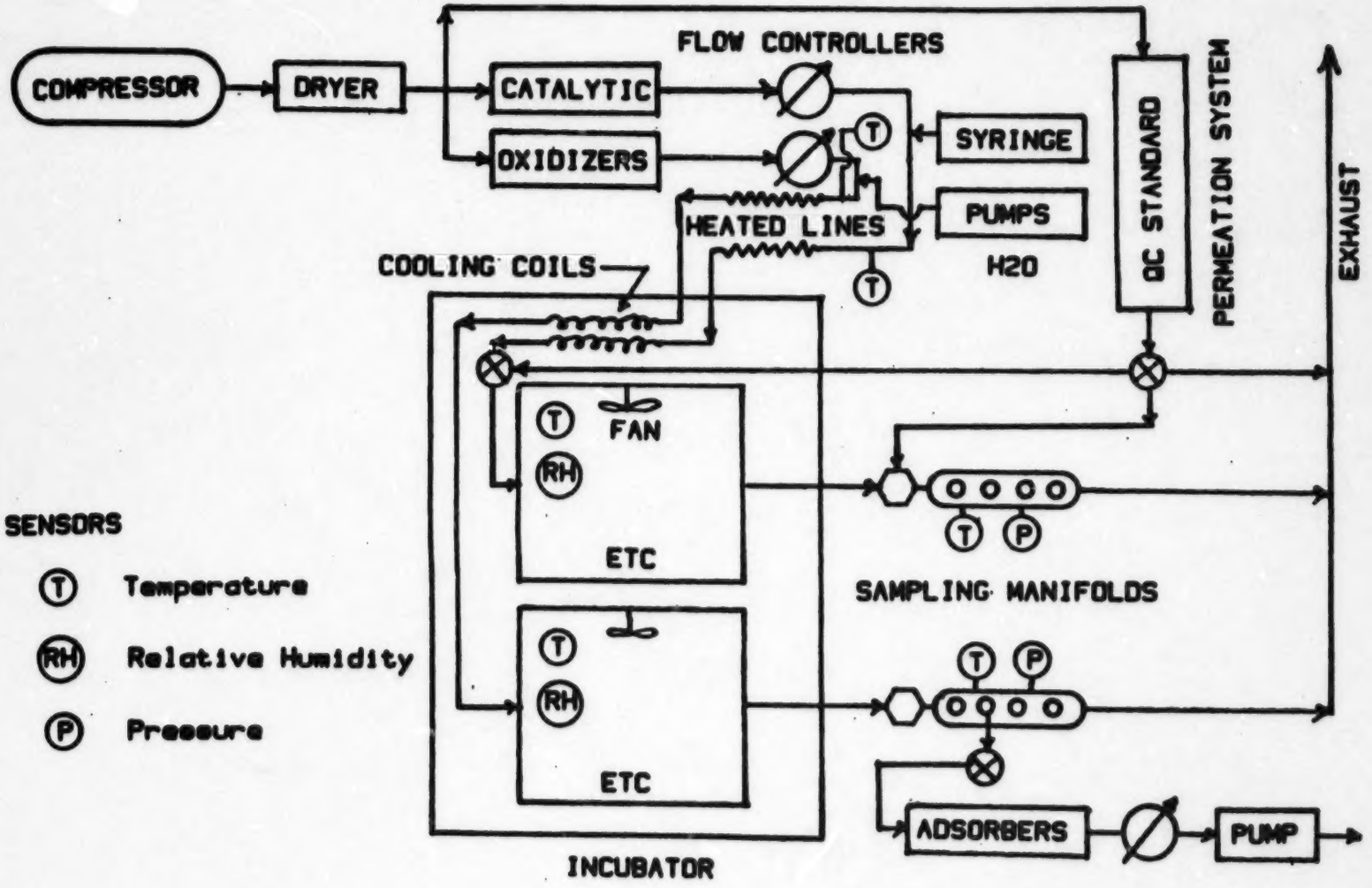

Figure 1. Test facility including environmental test chambers (ETC)

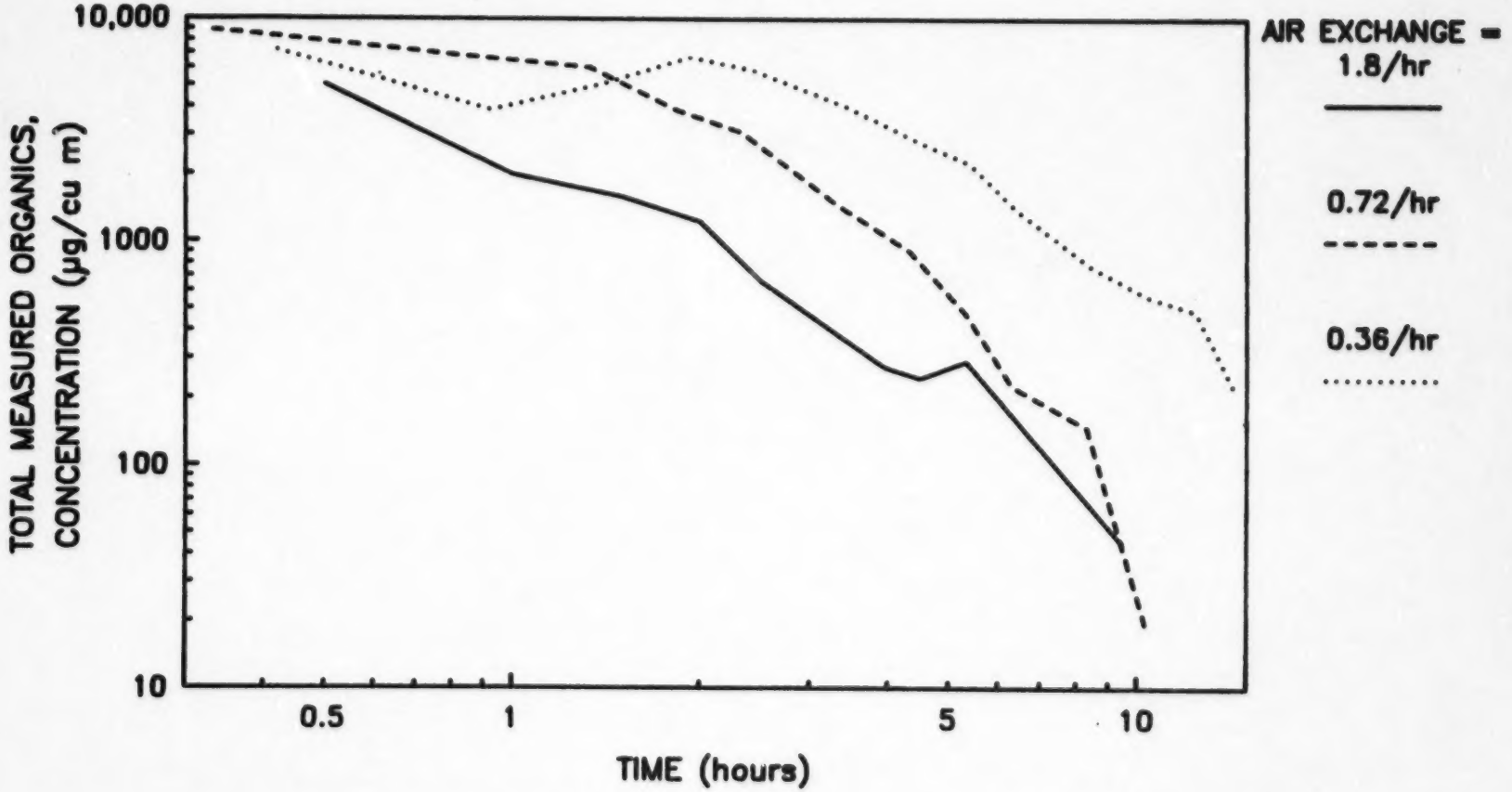

Figure 2. Chamber (ETC) concentration vs. time
floor adhesive
T = 23°C RH = 50%

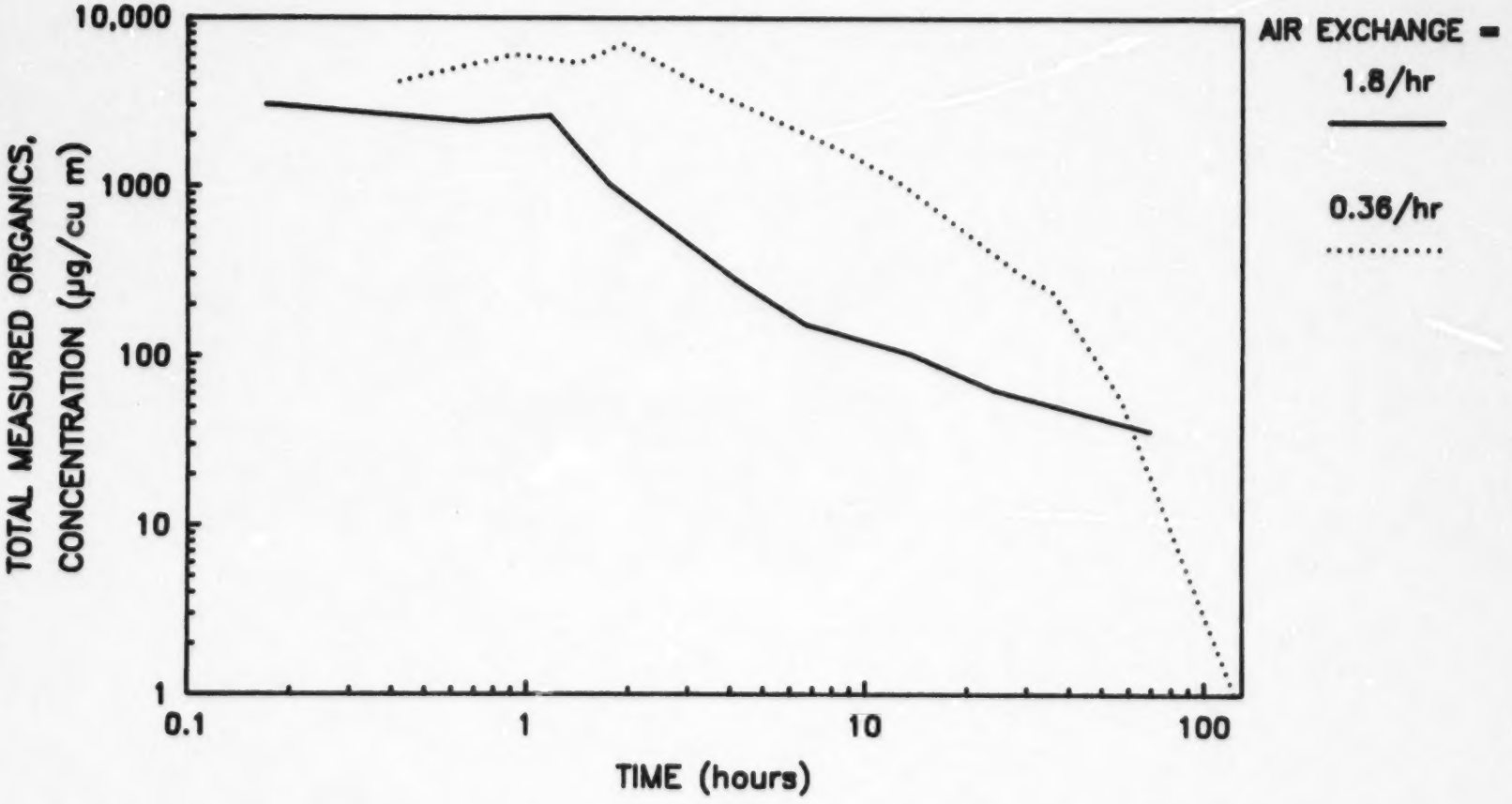

Figure 3. Chamber (ETC) concentration vs. time
clear acrylic latex caulk w/silicone
T = 23°C RH = 50%

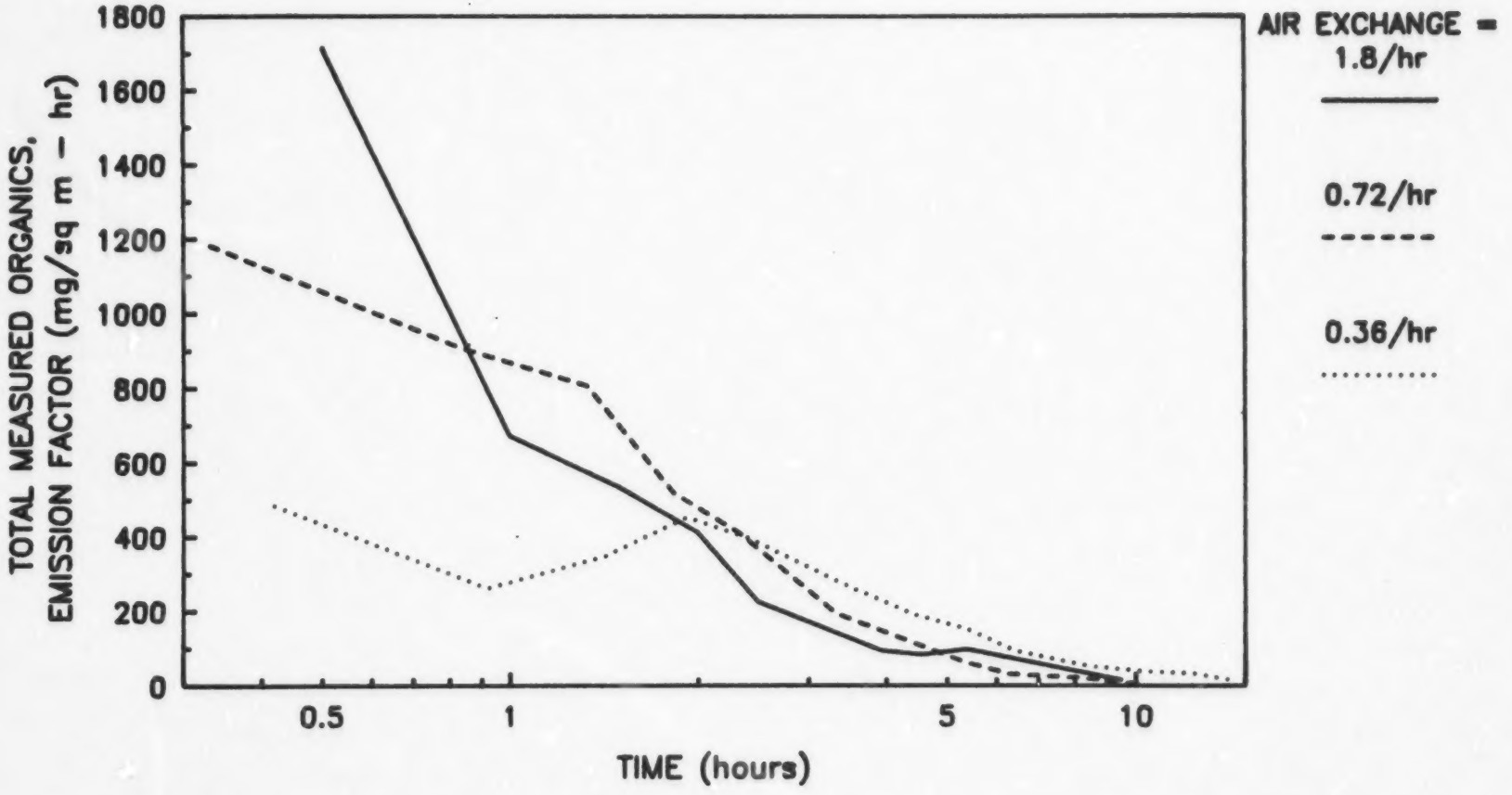

Figure 4. Emission factor vs. time
floor adhesive
T = 23°C RH = 50%

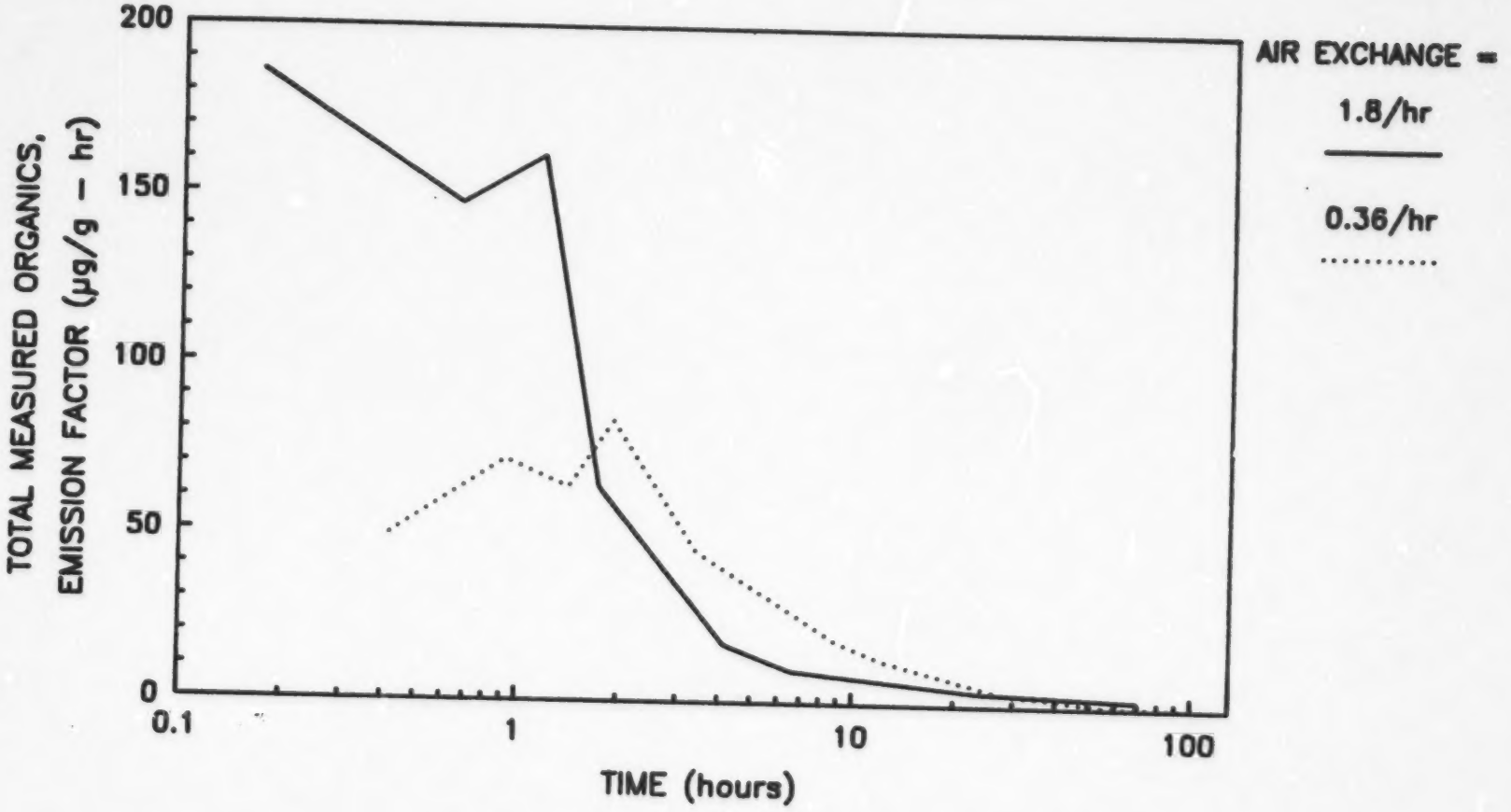

Figure 5. Emission factor vs. time
clear acrylic latex caulk w/silicone
T = 23°C RH = 50%

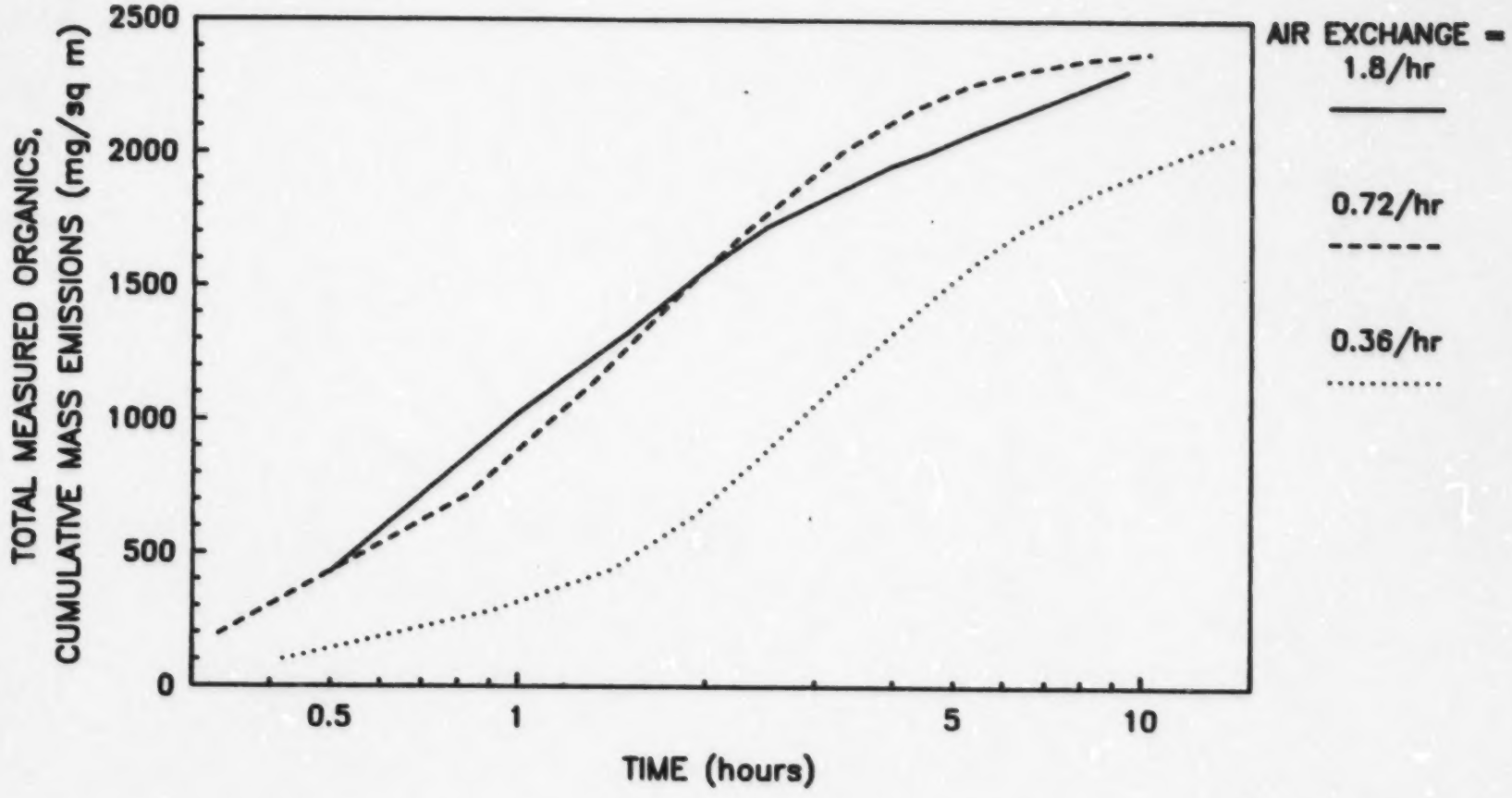

Figure 6. Cumulative mass emissions vs. time
floor adhesive
T = 23°C RH = 50%

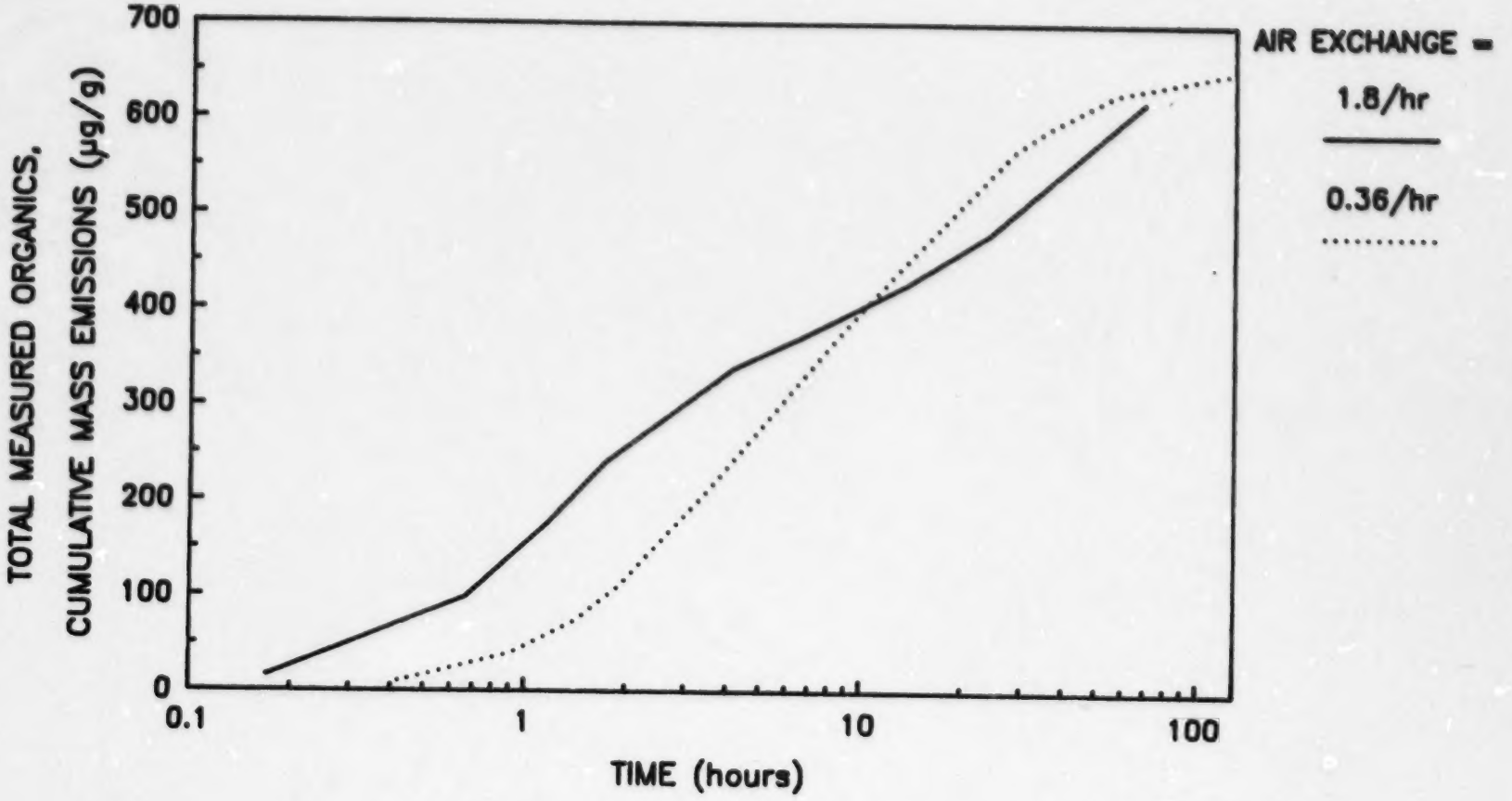

Figure 7. Cumulative mass emissions vs. time
clear acrylic latex caulk w/silicone
T = 23°C RH = 50%

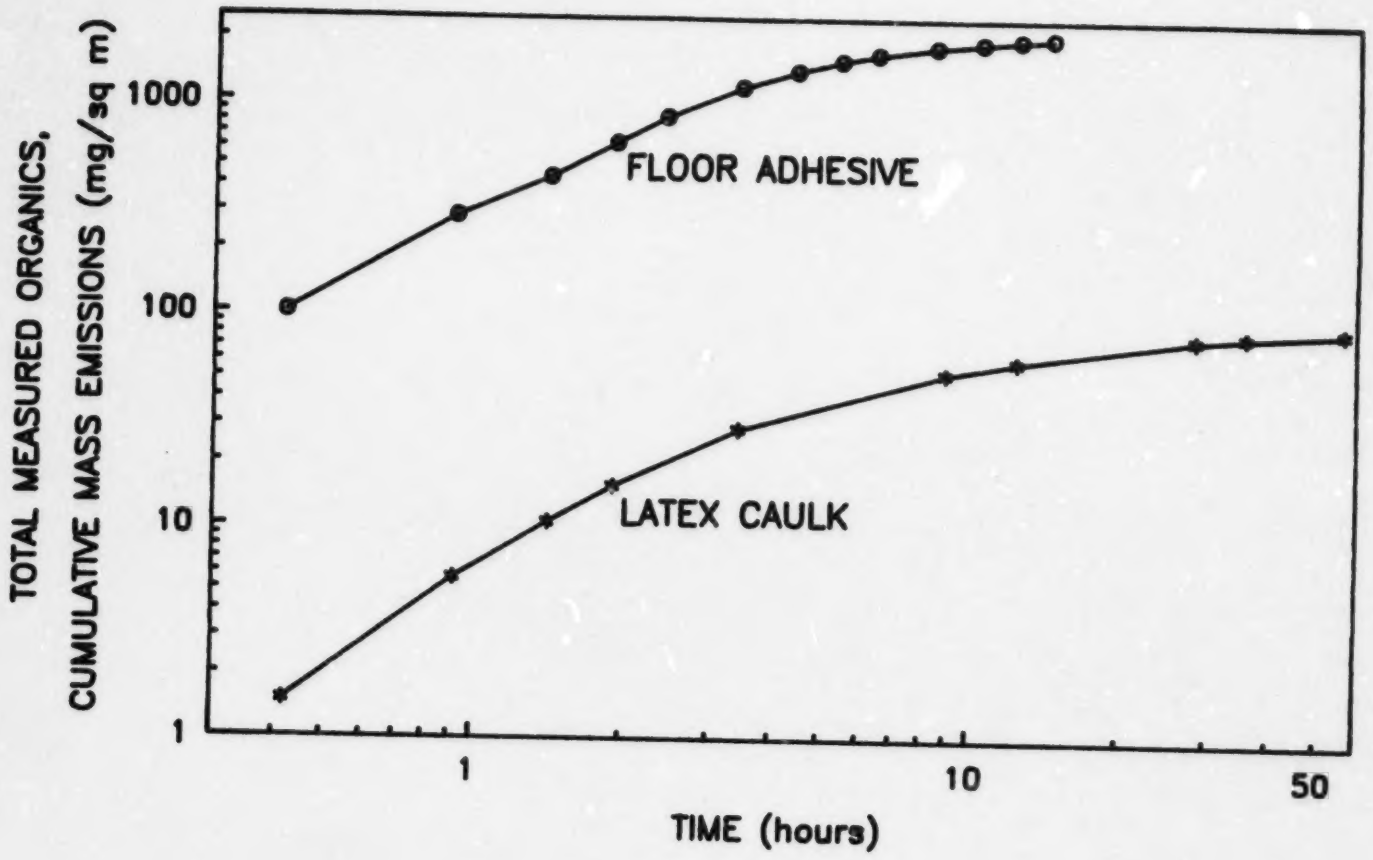

Figure 8. Cumulative mass emissions vs. time
two materials
T = 23°C RH = 50% Air Exchange = 0.36/hr